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THE
TROUT AND OTHER GAME FISHES
OF
BRITISH COLUMBIA

BY
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CONTENTS

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The studies on which this bulletin is based were carried out under the auspices of the Biological Board of Canada. Two summers were spent by the author in British Columbia, partly at the Pacific Biological Station, Nanaimo, and partly in visiting some of the principal game fish waters. From the inception of the studies in 1926 fishery officers, both federal and provincial, and numerous anglers have co-operated by supplying specimens and information.

The work has been carried out under the direction of Dr. W. A. Clemens, Director of the Pacific Biological Station, and for much of the time with the assistance of Mr. C. McC. Mottley.

J. R. D.

MOUNTAIN KAMLOOPS TROUT

Salmo kamloops whitehousei Dymond

The Trout and Other Game Fishes of British Columbia

INTRODUCTION

THE trout and their relatives attract more popular interest than any other group of fishes and it is therefore unfortunate that the differentiation of species and an understanding of their relationship to one another is unusually difficult in this group.

In western America there occurs a greater variety of these fish than is found in almost any other part of the world, and on account of the diversity of conditions, several of the species exhibit wide variations in coloration and size attained. It is not surprising therefore that there is much confusion as to the proper identification of the numerous forms of trout and troutlike fishes found in this area.

It is the purpose of this booklet to attempt to answer such questions as, how many kinds of trout occur in British Columbia, what are the distinctive characters of each, where do the various species occur, and what steps should be taken for their conservation?

Salmon, trout and char. In the waters of British Columbia there are three distinct groups of fishes belonging to the family Salmonidae, viz., the Pacific salmons, the trout and the char. There are five species of Pacific salmon (sockeye, spring, coho, chum, pink), three species of trout (steelhead, Kamloops and cut-throat) and three species of char (Dolly Varden, Great lake trout, and eastern speckled trout, the latter introduced).

One of the first causes of confusion in connection with these fish is the varied interpretations given the names salmon, trout and char. To get an understanding of the proper application of these names one must remember that they were first used in England as the names of three fish found in the waters of that country. The salmon was, of course, the Atlantic salmon which occurs not only in the waters about the British Isles and northern Europe generally, but in the Atlantic waters of eastern Canada. The trout was the brown trout of England, France, Germany and other middle European countries, and the char was the char which is found in a few of the lakes of north England, but which is much commoner in the lakes of Scotland, and especially in the alpine lakes of Switzerland and in Scandinavia.

The fish which are called salmon in British Columbia are only very distantly related to the original salmon, and it would have been better if these fish had never been called salmon, but had been given some other name such as quinnats. Although there are in Canada three such widely

distributed and well-known char as those listed above, the name char has never come into common use and these fish are very generally called trout. The char is a rare fish in England, and its name was probably unknown to the early settlers who came to America. All knew the trout, however, and it is not to be wondered at therefore that they gave this name to all the salmonoid game fishes which they found in our waters.

What constitutes a distinct kind or species of trout? The name of the trout is one of the first things which the angler or anyone else interested in trout wants to know. Let us suppose that one who has submitted a specimen for identification is told that it is a Kamloops trout. The reply is very likely to be, "But it is different from any Kamloops trout I ever saw," and one is face to face with the problem of trying to explain why fish that differ so widely should be regarded as being of the same kind or species, or why, on the other hand, two specimens which resemble one another so closely should be regarded as of distinct kinds or species.

One of the first things that should be said with reference to this question is that no two trout are ever alike. The trout raised from the eggs of a single female, fertilized by milt from one male would all be different. Not only would there be a great variation among the progeny of a single pair if they were reared in the same pond or lake, but there would be still wider variation among them if different individuals were reared under widely differing conditions. But no one would think of regarding as separate species two individuals of such a lot simply because they were of different sizes, different forms and different colours, when such differences were recognized as being the result of the conditions under which the trout had developed.

Differences in size, form, colour and similar characters, which vary with the conditions under which trout live, are therefore unsatisfactory in the separation of trout into different species.

There are differences between trout, however, which are not dependent on individual variation or on the conditions under which they develop. The difference between a Kamloops trout and a Dolly Varden is an example. Even under identical conditions in the same body of water these two fish are of totally different form, coloration and markings; they spawn in different places and at different times, have different feeding habits, and in practically all their characters differ more or less widely. It is true, as pointed out above, that the individual Kamloops trout in such a lake would show wide variation in form, colour, etc., and the same is true of the Dolly Varden, but the characteristics of the two species are so different that one would never find a Kamloops trout which so closely resembled a Dolly Varden that it would be impossible to recognize its

identity. There is no question as to whether two fish which differ so markedly from one another as these two do, should be regarded as of different kinds (distinct species).

No matter how distinct two kinds of fish are to-day, zoologists believe that they have descended from a common ancestor, just as the various breeds of domestic pigeons have been derived by selection from the common wild rock pigeon of Europe. In the case of species occurring in nature it has taken an infinitely longer time to produce the differences which characterize distinct species than has been required to produce the differences between the races of our domestic birds and animals.

The means by which the progeny from a common ancestor came to be, in the course of ages, so unlike as to be regarded as distinct species is not well understood. It is agreed, however, that some form of separation or isolation is necessary, for the same reason that it is necessary in the production of new and improved breeds of domestic animals, to isolate those animals having the characteristics of the breed desired for perpetuation, from those having other characteristics.

One of the most constant differences between distinct species is therefore their tendency to occupy different habitats, to choose different food and especially to breed in different places or at different times. Associated with these differences in habits, there are, of course, differences in form, colour, markings and other body characteristics, but two fish are not considered as belonging to separate species simply because they differ in some body character; it is more correct to say that fish show differences in body characters because they are of different species than it is to say that two fish are of different species because they differ in body characters. The real differences between distinct species are ingrained, deep-seated differences within the fish. Whether the external body characters are in any way linked to these internal differences is not known, but it is at least fortunate that there are these superficial marks by which different species may be recognized.

Since the differences which to-day characterize different species of fish have come about more or less slowly through the lapse of ages, there must have been a time when two forms which ultimately came to be very dissimilar were only slightly unlike each other. Also, since these changes are going on to-day just as they have always gone on, there must be among existing fish every gradation of difference from very slight differences, which no one would think of regarding as specific, to definite, well-marked differences which everyone recognizes as sufficient for the separation of species. How dissimilar must two forms be to justify us in regarding them as distinct species? That is a question on which there is no agreement, and on which there perhaps never can be agreement. Darwin in

1859 said, "in determining whether a form should be ranked as a species or a variety, the opinion of naturalists having sound judgment and wide experience seems the only guide to follow."

In trying to decide how many species of trout should be recognized in an area, two serious difficulties arise. In the first place, as already stated, there is no agreement as to how much or what kind of difference should be recognized as constituting separate species; this of course applies to all kinds of fish. In the case of the trout and its relatives there is a second difficulty, viz., their great variability. Great differences in size, shape, colour and similar body characters, which in most other kinds of fish are sufficient to indicate specific differences have been discovered in the case of salmonoid fishes to be quite capable of being produced directly by the conditions under which the fish has developed. It is always difficult in fishes to decide how much of the difference between two forms is due to environment and how much to heredity; in the case of trout this difficulty is much greater than in most fishes.

Discussion of classification adopted. In the present publication it is considered that there are three species of trout and three species of char in British Columbia, as follows:—

Trout—Steelhead, Kamloops, cut-throat.

Char—Dolly Varden, great lake trout, eastern speckled trout (introduced).

There is general agreement on the question of the species of char, but the same cannot be said of the trout. Some students of fish would consider that there were six or seven species, whereas others would regard all the trout as belonging to one species. It must be admitted, on the one hand, that the differences between the various forms of trout found in the province are not so great as the differences between the different kinds of char. It is, for instance, often difficult, and sometimes impossible, to distinguish the different kinds of trout from one another. On the other hand, some of those who would recognize more than one species of trout say that the differences between the various forms are sufficient to warrant the recognition of many more than three species. However, the writer believes that a more accurate understanding of the relationship of the various kinds to one another can be given by the classification adopted here than by any other arrangement that might be adopted.

Identification of species. In the differentiation of species certain structures and body proportions are ordinarily used, and it is necessary to understand these before attempting to identify a fish. Figure 1 illustrates a number of the external features used for this purpose.

The length of various structures, such as the head and fins, is usually expressed in relation to the length of the fish, for example as percentages of that length. For this purpose the length of the fish is measured only to the base of the tail or caudal fin; it does not include the tail fin and not necessarily the last scales, which in most scaled fishes encroach more or less on the base of the fin. The base of the caudal or tail fin is the point where the last vertebra ends and the caudal rays begin. It is only for the purpose of these comparative measurements that the length of a fish is so taken. For ordinary purposes the length of the fish is measured in inches to the end of the centre rays of the tail fin.

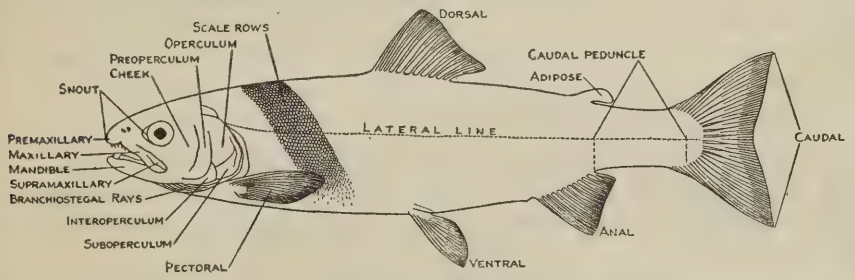

FIG. 1. Diagram of external features of a trout, illustrating some characters used in differentiating species.

The head is measured from the tip of the snout to the most posterior point on the border of the opercle. The measurement is made only to the edge of the bony part of the opercle, and does not include the flap of skin which borders it behind. The eye is measured lengthwise, and the snout from the tip of the nose to the front border of the eye. The depth is the greatest vertical distance through the body not including the fins. The width is taken at the widest part of the body. The caudal peduncle is the tapering portion of the body behind the anal fin. Its length is taken from a vertical from that point to the end of the vertebral column, and its depth is taken at its slenderest part. The height of fins is measured along their longest rays. In counting fin rays, only fully developed rays are usually counted, and this is taken to mean those which are at least two-thirds as long as the longest ray. In the present paper the number of shorter rays in front of the first fully developed ray is also given.

The number of scales is an important diagnostic feature. In the case of trout and char, their number is usually expressed as the number of oblique rows of scales running downwards and backwards to the lateral line. The latter is formed by a series of pores forming a raised line along the fish's side; each pore connects with a tiny sensory organ.

The gill-rakers are a series of tooth- or spine-like bony projections on the front or inner border of the gill arch (Fig. 2C). Their function is not

only to protect the delicate gill filaments from injury from within, but they serve to prevent small organisms and other food particles from being carried out between the gill arches by the respiratory current. Their number and length are related to the nature of the fish's food. Gill-rakers are counted both above and below the angle or bend of the gill arch; the number on the upper limb being mentioned first, thus "gill-rakers 10 + 18" indicates that there are 10 gill-rakers on the upper limb and 18 on the lower.

The vomer is a bone lying in the front part of the roof of the mouth in the middle. It usually has a broad head or front part and a tapering shaft behind. The shape of the vomer and the arrangement of the teeth on it are among the most important features by which the trout and char are distinguished. Figure 2, page 36, illustrates the essential features of the different types of vomerine bones and teeth in the trout and char.

The number of pyloric caeca is sometimes of importance in connection with the description of trout. These are blind, finger-like sacs opening into the alimentary canal at the pylorus or passage from the stomach to the intestines.

The following key may be found useful in identifying the trout and their relatives described in this booklet. On account of the variation met with in these fishes, it is difficult to construct a perfectly satisfactory key, but it is hoped that by means of the one given below, together with the descriptions and illustrations of the different species, it may be possible for anyone to identify for himself, practically any specimen of this interesting group met with in British Columbia.

Key to the Fishes Described in this Publication

A. Mouth large, maxillary reaching to a vertical through eye or beyond; teeth strong..... **Salmonidae**

B. Anal fin with fewer than 14 rays.

C. Vomer flat, the teeth on its backward extension in one or two rows (sometimes lost with age); mostly black-spotted.

D. Anal usually with 9 fully-developed rays; caudal unspotted; vomerine teeth little developed, those on the shaft few and deciduous..... **Salmo salar** (Atlantic salmon)

DD. Anal with 10 or more fully developed rays; caudal spotted; vomerine teeth numerous, persistent in a long double or zig-zag row.

E. No hyoid teeth or red under mandible; scales large, usually in fewer than 150 rows.

F. Scales usually in 130 to 135 rows (124–146).... **Salmo gairdneri** (Steelhead)

FF. Scales usually in 140 to 150 rows (130–160)... **Salmo kamloops** (Kamloops trout)

EE. Hyoid teeth and red under mandible usually present; scales smaller, usually in more than 150 rows..... **Salmo clarkii** (Cut-throat trout)

CC. Vomer boat-shaped, the shaft depressed and without teeth on its backward extension; species with reddish or pale spots.

G. Tail strongly forked; vomer with a raised crest extending backward from the head of the bone free from its shaft, this crest armed with strong teeth..... **Cristivomer namaycush** (Great lake trout)

GG. Tail square or slightly forked; vomer without raised crest, the teeth confined to a small patch on its head; species with red or salmon-coloured spots; the lower fins with bright edgings.

H. Back unspotted, marbled with dark olive or black irregular markings; dorsal and caudal fins mottled..... **Salvelinus fontinalis** (Eastern speckled trout)

HH. Back not marbled with darker..... **Salvelinus malma** (Dolly Varden)

BB. Anal fin with 14 to 17 developed rays..... **Oncorhynchus** (Pacific salmon)

AA. Mouth small, with weak teeth or none; scales large, in 70 to 90 rows.

J. Dorsal fin with 10 to 12 rays..... **Coregonidae** (Whitefish and ciscoes)

JJ. Dorsal fin with 20 to 25 rays..... **Thymallidae** (Grayling)

The various species of trout appear to be rather definitely limited in their distribution in British Columbia. The steelhead and the coastal cut-throat are limited to area 1, the Kamloops trout to area 2, and the Yellowstone cut-throat to area 3. At a few scattered points in area 2, indicated by black dots, a form of mountain cut-throat, distinct from either the coastal or Yellowstone cut-throats, is found.

STEELHEAD

Salmo gairdneri Richardson

Young in fresh water.

TROUT

STEELHEAD

Salmo gairdneri Richardson

In habits the steelhead is more of a salmon than a trout, most of its life being spent in the sea. It is found from Alaska to California, and, so far as known, occurs in all the coastal waters of British Columbia, including Vancouver island. It is not known how far steelheads ascend from the sea in the Fraser river, but it is probable that few, if any, penetrate beyond Hell's Gate; so that the species is confined to area 1 on the accompanying map.

DESCRIPTION

In the sea the steelhead is silvery in general coloration, with a bluish back. There are usually a few small, dark spots above the lateral line, and sometimes also on the top of the head. The caudal fin is marked with small spots, except for the outer one-third or one-quarter of the fin and there are usually faint spots also on the dorsal fin. The lower fins are white or clouded with dusky coloration. When the fish moves into fresh water, the blue of the back and upper sides changes to green, and a faint pinkish blush appears along the side, and on the gill cover, while the spots on the body and on the dorsal and caudal fins become larger, darker and more numerous. At spawning time, especially on males, the pink lateral streak becomes a deep reddish band, and the gill covers are similarly coloured. Because of the pink or reddish lateral band, the steelhead when in fresh water is usually called a rainbow trout.

Young steelheads in fresh water are olive-green above, and heavily spotted on the back and sides, and on the dorsal and caudal fins, as well as on the top and sides of the head. The spots above the lateral line are usually larger and more rounded than those on the lower sides, although there is considerable variation in the size and shape of the spots, which are sometimes quite small and stellate in shape. There are often a few spots on the lower fins, those on the pectoral being found along the anterior ray and on the anal at the base of the fin. The dorsal, anal and ventral fins have triangular, light-coloured areas at the tips, as shown in the illustration. Under some conditions these tips are yellowish or golden in colour. There is also a pinkish tint along the sides and on the gill covers. The young also have a series of black or dark-coloured parr marks along the sides. These vary from seven to thirteen in number, the average being about ten. They disappear when the fish are seven or eight inches in length, perhaps about the time they normally leave fresh water and migrate to the sea.

The steelhead has the typical spindle-shaped body characteristic of salmonoid fishes; head relatively small; maxillary in small fish extends to or slightly beyond a vertical through the posterior margin of the eye, in larger fish farther back and in spawning males reaches some distance behind a vertical through the posterior margin of the eye; at spawning time the male steelhead, like the Atlantic salmon, has the snout and jaws greatly enlarged, while the extremity of the lower jaw is hooked upward, the teeth in some specimens appearing to sink into the jaws, in others remaining quite large and strong. The fins of most steelheads are rather small, the average height or length of the various fins in percentage of the body length (to base of the caudal fin) being as follows: dorsal 11·9, anal 11·8, pectoral 14·8, ventral 12·4, caudal 18·5. The caudal is square or slightly lunate; in young ones somewhat forked. The dorsal fin usually has 11 or 12, rarely 13 developed rays; the anal 11 or 12; in both cases there are usually two shorter rays before the fully developed ones; gill-rakers 7 + 12 to 9 + 12; branchiostegals usually 11 or 12; the scales are usually in 131 to 134 diagonal rows, but there is considerable variation in the number, not only between fish from different localities, but between individuals from the same locality; the lower limit is about 124 and the upper 146.

LIFE-HISTORY AND HABITS

While its life-history has not been carefully studied, it is known that the steelhead in British Columbia spends most of its life in the sea, but resorts to fresh water to spawn.

The steelhead's visits to fresh water are not confined to its spawning migrations. In many localities it moves into streams at more or less regular intervals. Thus, at Port Alberni, on Vancouver island, according to Mr. Waterhouse, steelheads usually run into the river at the end of June or beginning of July, when the snows in the mountains begin to melt. There is also a run in September when the autumn rains begin, and often another in November. In many places steelheads accompany salmon on their spawning migrations. At Stamp falls, on Vancouver island, during the late summer of 1923, it was necessary to catch the sockeyes below the falls, carry them up, and place them in the river above. By August 4th, about nine thousand sockeyes and six hundred steelheads had been thus placed above the falls.

It is difficult to say just when steelheads begin running into fresh water on their spawning migration. Actual spawning occurs from January to May, the majority spawning probably in February or March. There are records of steelheads having been taken in spawning condition as late as May 24th, and some spawning is said to occur as early as December.

In most of the rivers frequented for spawning purposes, large numbers of steelheads are usually to be found in December, and some in November. By June, they have returned again to salt water.

It seems probable that the steelhead spends its first year in fresh water, migrating to the sea sometime during its second summer. At Cowichan hatchery in 1925, specimens from eggs spawned in February were from three to five inches long in September, while in 1926, young from eggs spawned in February were two to three inches long on August 24th. In many streams, specimens from six to ten inches in length are common during July. It seems likely that these are in their second year, and that they migrate to salt water at about that size, since only specimens very much larger are commonly taken in the streams. In September, and later, steelheads of twelve ounces to two pounds in weight are found in the estuaries, moving in and out with the tide, and may be seen rising like trout.

In the Eel river, California, in the early autumn, anglers catch a trout which is called a "half pounder." Prof. J. O. Snyder has determined that these are young steelheads, approximately three years old, which have entered the river on their first spawning migration. From a study of their scales, it was determined that most of these fish had spent two years in fresh water, and one in the sea. Steelheads with a similar history are found in the Klamath river in California. From an examination of the scales of one hundred steelheads from that river, Snyder concluded that these fish often spawn after having spent one year at sea, and that they usually enter the ocean at or near the end of the second year. Occasionally one migrates to the sea at the age of one year, and rarely one is found that has remained three years in the stream. None of those investigated had spawned before having spent a year in the sea.

As in the case of the Atlantic salmon, but unlike the Pacific salmon, steelheads spawn more than once. After their first spawning migration they usually spawn annually, but the number of years which they normally live is not known.

It is not known whether steelheads take food on their excursions into fresh water, but it is probable that they do eat when in fresh water at times other than on their spawning run. They are sometimes caught on hooks baited with salmon eggs, or on an artificial minnow.

There are few finer game fish than the steelhead. They rise readily to the fly both in fresh and salt water. The smaller sizes rise more readily to the fly than larger ones, and most of the large ones are taken by trolling or on bait. However, thirteen and fourteen pound fish have been taken on the fly, and it is probable that when anglers think more of their sport and less of the number or weight of fish which they take, that more and more of the larger steelheads will be taken on the fly.

In streams they are said to take the dry fly best when the water is low. They will also take the wet fly. In the Cowichan river, steelhead fishing is at its best in January, February and March. There, according to A. A. Easton, Fishery Inspector, they are taken on medium-sized salmon flies, the best being Parmachene Belle, Jock Scott, Silver Doctor, and Dusty Miller. The best method is said to be to fish above where one expects the fish to be, casting across and up stream and allowing the fly to sink well by the time it reaches where the fish is expected to be lying. Mr. Easton adds, "Steelheads are game fighters to the end, and good tackle is essential. I recommend a double-handed, sixteen foot rod, at least three hundred feet of medium salmon line and heavy sea trout casts. When hooked, these fish generally go away with a tremendous rush for perhaps sixty or seventy feet, and at the end of it leap high out of the water, and should they succeed in getting into rough and broken water, as they usually attempt to do, you have all your work cut out to hold them."

Steelheads have been transplanted to many parts of the world, including Europe, South Africa, Australia, New Zealand, as well as eastern North America, and in most of these areas have become established in a number of waters. In these places they are usually referred to as rainbow trout. In some of these localities fine-scaled rainbows, from such sources as the McCloud river, California, have also been introduced, and it is not unusual to find the steelhead persisting, while the fine-scaled rainbows disappear. Results differ of course from place to place, depending on conditions, but it seems that the steelheads are the most generally satisfactory of the rainbow trouts for such introductions.

The steelhead is of some importance as a commercial fish. In British Columbia it is sold chiefly in the fresh condition. Considerable quantities are shipped to eastern markets packed in ice, while for export to Europe they are frozen and glazed (covered with a thin coating of ice). They are also canned to a limited extent. In 1916 there were 5,986 cases of steelhead canned in British Columbia, but in 1929 the pack was only 672 cases.

The steelhead is said to reach a weight of thirty pounds, but the largest specimen of which I have been able to secure authentic information weighed 23½ pounds. It was caught by Mr. A. Bryan Williams, Game Commissioner of British Columbia. The average weight of specimens taken in the rivers on their spawning migrations is eight or nine pounds, although specimens up to fifteen pounds are not unusual.

KAMLOOPS TROUT

Salmo kamloops Jordan

The Kamloops trout is the common trout of the interior of the province, occurring throughout the Fraser drainage basin above Hell's Gate canyon, and throughout most of the basin of the Columbia in British Columbia. There is a small area in the southeastern part of the province, from which this species appears to have been absent originally, but, on account of fish cultural operations, it is becoming increasingly difficult to trace the original distribution of the different species in this and similar areas. The Kamloops trout, however, appears to be generally distributed throughout area 2 of the map on page 12 and to have been absent originally from areas 1 and 3. Area 3, in which the cut-throat was probably the only native trout, is that drained by the Moyie and Elk rivers, and part of the upper Kootenay.

Throughout the immense area in which the Kamloops trout occurs there is considerable variation in the species, but the differences are likely to be greater between two areas close together in which conditions are very dissimilar, than between two areas far apart in which conditions are alike. Thus the differences between the trout in a small lake and in a large lake, situated within a few hundred yards of one another, are likely to be greater than the differences between the trout in two large lakes hundreds of miles apart.

DESCRIPTION

On account of the great differences between Kamloops trout from different habitats and areas within its range, it is impossible to give a general account of the characteristics of the species. The following description applies to the fish found in the larger bodies of water, such as Kootenay and Okanagan lakes.

Even in such lakes, confusing differences occur among individuals of the same species. The small, heavily-spotted, greenish-coloured fish, often found in streams flowing into these lakes, are called brook trout; the large, blue-backed, lightly-spotted, silvery fish are called silver trout, or silver salmon; the fish with distinct lateral bands are called rainbow trout; and the very dark-coloured ones, black trout. The red lateral band, and the dark coloration, are part of the spawning dress of the species; the silvery colour is characteristic of the larger fish out of the spawning season, and the heavy spotting and greenish colour, of small fish in shallow water.

The silvery fish usually have bluish backs, a coloration which corresponds to that of the steelhead in the sea. It is probable that this coloration is due in some way to life in a large, comparatively deep body of

water. Most species of fish, whether marine or fresh-water, which live in the open waters of the sea or of a lake, or even of a large river, have this silvery type of coloration. It is possible that the greenish colour, and the heavier spotting of the steelhead in fresh water, are not due so much to the fact that the water is fresh, as to the fact that the fish is living in shallower water, and hence exposed to more light. Similarly, small trout in streams and small lakes, and the shallow parts of large lakes, are greenish and spotted, due to the greater intensity of light to which they are exposed. The same cause may very well be responsible for the dark colour of the Kamloops trout, when it moves into the shallow parts of streams for spawning. It suggests the tanning of human beings when exposed to strong sunlight.

The typical silvery fish of large lakes is bluish above, with light silvery sides and belly. The spots are comparatively small and x-shaped, and are located chiefly above the lateral line, although there are a few below the line in front, but more posteriorly on the caudal peduncle. There are also a few rounded spots on the top of the head and behind the eye. The dorsal and caudal fins are spotted; the anal usually has a few spots at the base and the pectoral on the anterior ray; the ventral is usually without spots. Except for the spots, the fins are white or faintly clouded. The chin and lower jaw are usually quite black.

In the "rainbow" type of coloration, there is a pink or reddish band along the sides and on the gill-cover. This band varies from a faint, pinkish iridescence to a deep red, depending on the proximity of the spawning period of the individual. Even silvery fish usually show a pinkish iridescence along the sides. The upper parts are usually greenish, and the spots larger and more numerous, extending often to well below the lateral line. The lower fins are also more spotted than in silvery fish; the ventral sometimes shows a few spots. In general coloration these fins are often pinkish, but sometimes quite darkly clouded. The tips of the ventral and anal fins are cream-coloured. Sometimes these light-coloured tips extend half the length of the first ray.

Small fish of nine to twelve inches in length show some variation of one or other of the above types of coloration and, in addition, have many bluish blotches below the lateral line. These appear to be associated with the parr marks, and to persist after the parr marks themselves have disappeared. Fish smaller than nine inches in length usually show a series of dark bars or parr marks along the sides. The number varies from eight to thirteen, but is usually nine or ten. These small fish are greenish in coloration and often heavily spotted, sometimes with a good deal of red along the sides. The tips of the anal and ventral fins are orange or salmon coloured.

KAMLOOPS TROUT

Salmo kamloops Jordan

"Rainbow" coloration; a recently spawned fish.

In general body shape the Kamloops trout is quite similar to the steelhead. In specimens up to twelve or fifteen inches in length, the heads of the two species are of approximately equal length, but in larger specimens, the head of the Kamloops is decidedly longer than that of the steelhead. With the setting in of sexual maturity the head of the Kamloops begins to increase in length relative to the length of the fish. This tendency is more marked in the case of the male, so that large spawning males come to have very large, heavy heads, with prominently hooked lower jaws. This increase in the size of the head is more pronounced in the Kamloops than in the steelhead. The following table indicates the extent of the differences between the size of the heads, and of the head parts in the case of the two species. The measurements are in percentages of the body length:—

Species	Length (inches)	Sex	Head length	Head depth	Snout	Maxillary	Interorbital
Steelhead	27	Female	21·0	14·8	6·5	11·0	8·3
"	30	Male	24·0	15·5	8·8	14·8	8·8
Kamloops	25	Female	24·8	16·1	7·8	14·1	8·7
"	29	Male	28·5	18·0	11·0	18·8	9·8

At all sizes the maxillary of the Kamloops extends farther back than in the steelhead.

The fins, except for the anal, are longer in the Kamloops than in the steelhead, the average length of the different fins in percentage of the body length being as follows: dorsal 12·4, anal 11·7, pectoral 16·0, ventral 13·0, caudal 20·0. The caudal fin in large specimens is almost square; in small ones somewhat forked. The usual number of developed rays in the dorsal fin is 10 or 11, with 2 or 3 shorter rays in front; anal 10 or 11, with 1 to 3 shorter rays; gill-rakers 7 + 11 to 9 + 12; branchiostegals 11 or 12. The scales vary considerably in number, but in fish from Kootenay, Okanagan, Paul, and similar lakes, they usually average about 145 diagonal rows, ranging from 130 to 160, ninety per cent, however, have from 135 to 153 scale rows. At spawning time the skin of the back becomes thick and spongy and the scales partly embedded in it.

LIFE-HISTORY AND HABITS

Little is known about the life-history of the Kamloops trout. Spawning occurs in creeks from April to June, the exact time varying with the locality and the season, but May or early June is the usual spawning time. Fish from small lakes commonly spawn in the shallow water of outlet creeks quite close to the lake. It is commonly stated that some trout spawn on the beaches of larger lakes, near the mouths of inflowing streams, and it is possible that such is the case.

By August, the fry are from $1\frac{1}{2}$ to $2\frac{1}{2}$ inches in length. It is not known how long they stay in small streams connected with lakes, but the indications are that most of them seek the lake before the end of their first year. This is a critical phase in the life history of the trout, and one on which it is important to obtain information. We require to know, for instance, how long the fry stay in the creek, what they eat in the creek, and when they first reach the lake, and whether there is an adequate supply of such food in the creeks and lakes.

In some cases trout spend their whole lives in the small streams. For instance, trout occur above falls which they are not able to surmount at high water; some must pass their whole lives in the portion of the stream above these falls, else the race would become extinct in such places. It is probable too that even where trout have access to a larger body of water, some of them never go down to it, but remain small and stay continuously in the stream.

Little authentic information is yet available on the food of this important game-fish. Since in lakes so many of them are taken at or near the surface in May and June, not only on the fly but on the troll as well, it is probable that a large percentage of their food at this period consists of insect material. Anglers report that many of the trout taken in Kootenay lake in May have their stomachs packed with winged ants. It is to be expected too that insects, both aquatic and terrestrial, form the bulk of the food of specimens under sixteen inches in length at all seasons, but the staple food of the larger specimens is probably fish. In most of the lakes in which the Kamloops reaches any considerable size, the kokanee (*Oncorhynchus nerka kennerlyi*) occurs in very large numbers, and is preyed on by the large trout. Quite a number of stomachs of Kootenay lake trout of over sixteen inches in length have been examined, and almost invariably those that were found to contain food, had eaten kokanees. As many as three of these fish have been found in a trout stomach, and some of them were over six inches in length. Metzelaar has found that the rainbow trout (steelhead) in Michigan eats insects, crayfish, etc., until it reaches a length of about seventeen inches, after which it turns to a fish diet.

The rate of growth, and the size attained, depend largely on the amount of food available, and perhaps to some extent on other conditions. As a general rule the size to which trout grow varies with the size of the body of water in which they occur. In small streams and lakes the trout are small; in large rivers and lakes they are large; the largest, as a rule, being found in the largest bodies of water. This is perhaps in the last analysis a question of food. In small streams and lakes there is little food and usually a considerable number of trout; for there are generally no enemy fish to devour them. The result is that there is insufficient food for the number of fish, and the trout are dwarfed. In larger bodies of water there

is not only more food, but a greater range in the size of the food. Thus, in most of the large lakes and rivers there are plenty of kokanees, ranging in size from tiny fry or fingerlings to a length of seven or eight inches, and in exceptional cases to a foot. A supply of food of such a size seems to be essential if trout are to reach any considerable size under normal conditions. In most trout waters the supply of insect and other food of similar size is such that a trout cannot find enough of it to produce more than a moderate growth. It is only when such organisms occur in unusual numbers, as in the barren lakes referred to later, or when large food items such as fish, are obtainable that trout can grow to a size of more than sixteen or seventeen inches.

In the case of many kinds of fish, including the Atlantic salmon and the European trout, it has been found possible to determine the age of a fish, and hence its rate of growth, by an examination of its scales. On the surface of the scales is a series of raised lines; when the fish grows rapidly, as in spring and summer, these lines are farther apart than when the fish makes a slow growth, as in winter. By counting the number of winter areas, or regions on the scale where the lines of growth are close together, the number of winters through which the individual has lived is determined. Such age determinations have proved to be unusually difficult in the case of the Kamloops trout, and to date we are not in a position to say how long it takes a trout to attain a certain size. We can say, however, without the aid of the scale-method of age determination, that the rate of growth varies from one body of water to another, just as the size to which they grow varies.

Interesting information is available on the rate of growth sometimes attained in so-called barren lakes, i.e., lakes in which trout did not occur until they were introduced artificially. Many of these lakes contain abundance of food, the absence of trout from them being due probably to the lack of suitable spawning grounds, or to other causes connected with the reproduction of the species. When trout are planted in such lakes they often make a phenomenal growth. The following is information secured from a number of such lakes:—

Lake	Date planted	Date caught	Weight	
			lbs.	oz.
Snowshoe lake	May 30, 1926	July 24, 1928	3	4
"	" 30, 1926	" 24, 1928	2	9
"	" 30, 1926	" 24, 1928	2	5
"	" 30, 1926	" 24, 1928	1	12½
Horseshoe lake			6	8
"			4	8
"			4	4
Manistee lake (near Fernie)	July 8, 1925	Sept., 1927	13	1
Jewel lake (near Grand Forks)	1924	1928	13	10

Mr. H. J. Ryder, of the Fish Cultural Service, Department of Fisheries, gives the following as the weight of fish of various ages in Horseshoe lake, one of the "barren" lakes referred to above:—

1 year	½ lb.
2 "	6 lbs.
3 "	13 lbs.

Such phenomenal growth rates as these are not confined to lakes from which trout have previously been absent. The greatest authentic weight which I have been able to obtain for this species is that of a specimen taken in Premier lake near Cranbrook, which contained only cut-throat until Kamloops were introduced into it. This specimen weighed 35 pounds 8 ounces.

Such rapid increases in weight are, however, not maintained in these lakes if plantings are continued. This is no doubt due in the case of barren lakes to the fact that the trout consume the superabundance of food originally occurring in them, and there is gradually established a more normal ratio between available food and number of trout.

The increased size of non-native trout introduced into waters in which trout already occur, is more difficult to explain, but the same thing happens in the case of birds and other animals placed in new environments. Such introduced species often thrive better in their new homes than in their native ones, and, in the case of many insects and that of rabbits in Australia, become serious pests. Nature, however, always strives for a balance and such introduced species almost invariably attain ultimately to more normal numbers and rates of growth. As a matter of fact, the attainment of abnormal numbers or size on the part of the introduced species must be at the expense of some native species, and the ultimate result often is that the total yield of introduced and native species is together less than that of the native species under original conditions. Such, according to Mr. Higgs, has been the result of the introduction of eastern speckled trout into the Tum Tum creek, a slow-running, swampy creek draining into the Columbia river near Revelstoke. When introduced into this stream the eastern speckled trout thrived wonderfully. The native Kamloops, according to Mr. Higgs, never exceeded a pound in weight, but the newcomers were taken up to two pounds. The present situation, however, is that the native trout has so decreased in numbers, that the combined catch of the two species is not usually as large as when the Kamloops made up the entire catch. Such a result is probably to be explained on somewhat similar grounds to that in the case of barren lakes. The increased growth at first obtained must be at the expense of the stock of food animals in the lake or stream, and not enough of them are left to

KAMLOOPS TROUT

Salmo kamloops Jordan

Coloration of medium-sized fish in rivers and small lakes.

reproduce themselves normally; so that less trout food is produced than formerly, resulting either in the dwarfing in size or reduction in numbers of the trout or both.

The question is sometimes asked as to the size at which Kamloops trout begin to spawn. In view of the above discussion as to the widely different rates at which trout grow under different conditions, it is apparent that the size at which trout attain sexual maturity will vary widely. It is a question of age rather than of size. Here again we are at a loss when we try to give definite ages, because of the difficulty of reading the scales. From observations of trout in barren lakes, it has been learned that a few males are ripe when three years old, but that most individuals do not spawn until four years of age. This is believed to be the age at which most trout spawn for the first time under natural conditions, although it is to be expected that under certain circumstances the age of maturity would be delayed until the fifth year.

Attention has been drawn to the fact that, as a rule, the trout of small lakes and streams never attain a very large size. In fact, in some bodies of water they mature and reproduce at a few ounces in weight. In Six-mile lake, near Nelson, the largest female we have seen was $10\frac{1}{2}$ inches in length, and the largest male nine inches, and the majority are much smaller than this. Fish differ from birds and mammals in being able to survive and to reproduce more or less normally in spite of severe dwarfing. For each species of bird or mammal, there is a more or less definite size to which they grow. Variations in size of course do occur, but a robin or a squirrel, for instance, which does not get enough food, either dies of starvation or becomes stunted and entirely abnormal. But fish are not affected in the same way by dwarfing. They mature and reproduce quite satisfactorily, even though they do not reach a size at all approximate to that which is usual for the species. It is a mistake to think of a small fish as necessarily a young one. A small specimen may be older and more mature sexually than a much larger one of the same species. This is far more striking in the case of fresh-water fishes, for which conditions vary much more widely from place to place than they do in the sea.

Although we have seen that fish are able to reproduce in spite of severe dwarfing, the question naturally arises as to the effect of dwarfing on the progeny. Will trout produced by eggs from dwarfed fish grow as large under similar conditions as those from the eggs of large trout of the same species? Only carefully controlled experiments can answer that question, and such experiments have not yet been carried out. It is known, however, that the progeny of trout which have for many generations been small, can under suitable conditions reach a very much larger size than their parents. It is possible, however, that trout reared from the

eggs of specimens whose ancestors for thousands of years have been dwarfed, as must be the case in many of the mountain lakes of British Columbia, will not reach the size, no matter how favourable the conditions, of specimens produced from eggs of much larger trout. However, until carefully controlled experiments have been carried out, it will be impossible to say to what extent the size of trout is due to environment, and what to heredity.

As a game fish the Kamloops trout stands pre-eminent. Its method of fighting is quite similar to that of the steelhead; both make terrific rushes and both usually jump several times, but in the opinion of many, the Kamloops is the gamier. A. Bryan Williams, Game Commissioner of British Columbia, says, "I think the Kamloops trout is the more active of the two. I have had them make as many as fourteen clean jumps out of the water, some of these jumps being to great heights. I am inclined to think that the Kamloops trout is a harder fish to handle than the steelhead, though both require considerable skill to land."

The Kamloops is taken on the fly and by trolling. The best fly fishing is to be had on the streams and smaller lakes, and at the mouths of streams flowing into larger rivers and lakes. Trout up to three or four pounds are commonly taken in such situations, but much larger specimens, up to ten pounds and over, have been taken on the fly. One of the best methods of fishing the streams, is to work the fly through the current near the large holes with a series of short jerks. Fish are also hooked by allowing the fly to sink and drift in the current.

On the larger lakes, the big trout are usually taken by trolling, and the best fishing for them is had during May and June, and again in September. In the warmer weather they appear to seek the deeper waters, where they are occasionally caught by deep trolling. In test nets a Kamloops trout was taken at a depth of one hundred feet in Okanagan lake on July 9, 1928.

On medium sized lakes, trout are taken on the fly during May and June, and by trolling during July and August. On Paul lake, near Kamloops, eighty-five per cent of the fish taken during May and June are taken on the fly, while in July and August, ninety per cent are taken on the troll. The best fly fishing on this lake is at the outer edge of the shoal area where it breaks into deep water.

In trolling, one hundred yards of line on a large reel and fairly light rod is the tackle favoured by most anglers. From two hundred to two hundred and fifty feet of line is let out and, as a rule, no sinkers are used as the trout, except during the hot weather of summer, are usually to be taken near the surface.

When hooked, the Kamloops trout makes a terrific fight for freedom, combining a series of mad rushes and wild leaps with a violent shaking of the head, in an effort to dislodge the hook. When possible, it makes for the swiftest water where the current adds to the weight of its body to test the angler's skill. In the experience of Mr. Higgs, "He strips line from reel with amazing speed, and when you have begun to despair of him ever tiring, he turns suddenly and it behooves you to show your skill at regaining line, for this trick has been responsible for more than one angler's returning home with a story of 'the big one that got away.' . . . . Fully half of the Kamloops trout that are hooked are never landed; for the terrific shaking to which it subjects the spoon when leaping, serves to dislodge any but the most deeply embedded hook, and it is no uncommon sight to see the spoon go sailing into the air in the midst of these wonderful leaps. When it has seemed to have exhausted all the tricks and acrobatics of its tribe in its bid for freedom, and just as the landing net is being placed beneath its silvery sides, there is a sudden flip of the tail, a wild thrashing of the water into foam, and he is away again."

There is an increasing appreciation of the high qualities of the Kamloops trout, and a growing sentiment for its conservation. It has too high a value as a game species to be sacrificed as a commercial fish, as is still being done on some of the larger lakes. It is learned, for instance, that commercial fishermen have made as much as $500 in a single month trolling for Kamloops trout, which were sold at twenty-seven cents per pound. Most of the commercial fishing is done during the autumn and winter, November being the best month. There are too many large trout being taken also during the early summer and autumn by so-called sportsmen. Trolling from motor boats yields the maximum weight of fish with a minimum of sport. The time will come, one hopes, when the sentiment of the higher type of sportsmen will prevail, and there will be more angling with the fly, and trolling from row-boats. The trout cannot permanently sustain the present drain per individual fisherman on their numbers; for the number of fishermen will increase. The logical thing to do, therefore, is to adopt methods that will give fewer fish but more sport per fish.

There is some doubt as to the maximum weight attained by the Kamloops trout. One hears of forty pound fish being handled by hatchery officials, but these, unfortunately, are merely estimates. A "black salmon" (one which had spawned recently) weighing twenty-eight pounds has been taken in Kootenay lake. In 1927 Mr. D. McDonald took a "silver salmon" weighing twenty-six pounds and five ounces, and on May 7, 1928, Mr. Cocklan caught one weighing twenty-one pounds four ounces in the same lake. The largest specimen taken in Okanagan lake, according to Mr. George Gartrell, weighed thirty-two pounds. In October, 1929, Mr.

Joseph Kline, of Cranbrook, took a Kamloops trout weighing thirty-five pounds, eight ounces, in Premier lake. This lake originally contained cut-throats, the Kamloops having been only recently introduced into it. The weights attained in a number of so-called barren lakes are given on page 21.

In smaller lakes, and in rivers and small streams, the maximum size reached is roughly in proportion to the size of the body of water, as already mentioned. Following are the maximum sizes reported for a number of waters in different parts of the province: Stuart lake, seventeen pounds; Trembleur lake, near Prince George, thirteen pounds; Paul lake near Kamloops, seven pounds and twelve ounces; Canyon of Kootenay river below Bonnington falls, twelve pounds, four ounces; Columbia river in neighbourhood of Revelstoke, two pounds; Six-mile lake, a small lake at a considerable elevation, one foot. T. W. Lambert in "Fishing in British Columbia" (London, 1907) reports some weights as follows: Thompson river, near Spence's bridge at the mouth of the Nicola river, ten pounds; Marble canyon lake, twenty-two and a half pounds; Long lake near Vernon, twelve pounds.

Mountain Kamloops trout (*Salmo kamloops whitehousei* Dymond). As already mentioned, the Kamloops trout shows wide variations in body form, markings and coloration, depending apparently on the size and character of the waters in which it is found. The question as to whether some of the striking variations exhibited are in the nature of specific differences has been discussed (page 17) and the conclusion reached that they are not. Every gradation of difference between the most extreme forms is found. It has seemed advisable, however, to designate the extremes by subspecific names and, therefore, the small, heavily-spotted, brightly-coloured Kamloops trout, characteristic of small lakes at high altitudes, has been designated as the Mountain Kamloops trout (*Salmo kamloops whitehousei*), the typical form of large lakes at lower altitudes being then recognized as (*Salmo kamloops kamloops*).

The Mountain Kamloops trout is found in such lakes as Six-mile lake near Nelson, and Bear and Fish lakes near Kaslo. These are all small lakes lying at considerable elevations. These trout are quite small, seldom reaching a foot in length. They are quite slender-bodied, being considerably shallower and more compressed than trout of the same size from Kootenay lake. The head is also longer and deeper, especially in the males, and appears larger than it really is by contrast with the slender, compressed body. The parr marks are persistent even in spawning fish, on which the red lateral band is interrupted by these dark bars. The general coloration is olive-green above, fading to a yellowish-green on the lower sides. These trout are fairly heavily spotted, as shown in the illustration.

COASTAL CUT-THROAT TROUT

Salmo clarkii clarkii Richardson

A conspicuous feature of their markings is the orange tip to the dorsal fin, and the lighter, almost white tip of the ventrals and anal. This white tip spreads so far along the anterior margin of the ventrals and anal, as to suggest the white-margined lower fins of the eastern speckled trout (*Salvelinus fontinalis*).

These trout are also finer scaled than the typical Kamloops, their scales being arranged on the average in about 150 diagonal rows, although there is considerable variation in this respect, the number varying from 140 to 164; gill-rakers 7 + 10 or 7 + 11; branchiostegals 10 or 11.

As already indicated, the specimens here described represent the extreme of a tendency shown by trout in a number of smaller lakes at some elevation. For instance, in the vicinity of Princeton are a number of lakes and streams tributary to the Similkameen river, in which the trout show some of the tendencies of the form here described. The trout of Bear lake in this district, while not dwarfed as they are in Six-mile lake near Nelson, have very large heads as compared with Kamloops trout of the same size, from Kootenay and Okanagan lakes. They also have increased numbers of scales, these usually being in about 160 diagonal rows.

CUT-THROAT TROUT

Salmo clarkii Richardson

The cut-throat trout is common in the coastal waters of British Columbia, but in the interior is not of general distribution, occurring only in isolated localities. Outside our area, it ranges to Alaska and Kamchatka, and southward to California.

It owes its common name to a red coloration between the lower jaw and the isthmus, the colour sometimes extending on the isthmus beyond the line of the jaw, thus giving the effect of a reddish gash on each side of the jaw. This red coloration is quite variable; often it does not extend beyond the jaw, which must be raised in order that the coloration may be seen. Sometimes, especially in specimens from salt water, the red is reduced to a pale pinkish spot, or is entirely absent. Another character possessed by most specimens of cut-throat trout, is a patch of hyoid teeth on the back of the tongue (fig. 2C, page 36). These, too, are sometimes absent, but, whenever found, serve to distinguish the cut-throat from either the Kamloops or steelhead.

The cut-throat is distinguished by other characteristics as well—by the shape of its body, the character of its markings and coloration, the number of scales, and, especially, by its habits and distribution, but as there is so much variation in most of these characters between specimens from different localities, it is best to describe separately the different geographical races into which this species is divisible.

Coastal cut-throat trout (*Salmo clarkii clarkii* Richardson). This variety of the cut-throat is found in practically all the streams and lakes of Vancouver island, and in the coastal waters of the mainland. The latter include the Skeena and its tributaries, and all rivers between the Skeena and the Fraser. In the Fraser system, it does not appear to be found beyond Hell's Gate, but is common in Harrison and Chilliwack lakes and rivers.

DESCRIPTION

The coastal cut-throat trout when taken in fresh water is usually heavily spotted. The spots are generally rather small and stellate in shape, and closely placed on the sides to well below the lateral line. The dorsal and caudal fins are heavily spotted too, many of the spots, especially at the base of the fins, being rounded. The anal also is sometimes quite heavily spotted, and the pectoral and ventral bear spots at their bases. There are rounded spots on the snout, top of the head, cheeks and opercles, and sometimes on the chin and lower jaw.

The colour is an olive-green on the sides, darker green above and silvery below. The sides of the head have pinkish reflections, and the paired fins are reddish orange. The tips of the anal and ventral fins are often orange or yellowish, but these markings are usually less conspicuous than similar ones on the steelhead and Kamloops. The cut-throat, where it has access to the sea, commonly resorts to salt water, and there takes on a coloration similar to that of the steelhead in the sea. Specimens of every gradation of colour, between these faintly spotted, silvery, blue-backed fish of salt water, and the heavily spotted, green-coloured fish of fresh water are found. Many of the larger cut-throats taken in lakes and streams, although of a general greenish coloration, have a pronounced silvery sheen to their sides due, probably, to a recent sojourn in salt water.

In comparison with the steelhead which is likely to be found in the same waters, the cut-throat has a longer head, the snout and jaws being especially long as compared with those of the steelhead. In the cut-throat, the jaw usually extends to well behind a vertical through the posterior margin of the eye. The general body shape is different, being in the cut-throat more rounded, i.e., wider and not so deep, as compared with the steelhead. These differences are well shown in the following table, which gives in percentages of the body length (to the base of the tail fin) the lengths of a number of the body parts of the two species. As explained elsewhere, the percentage of the total length which the head constitutes, as well as the general body form, varies as the fish grows. For that reason, values are given for fish of different lengths.

Body proportions of steelhead and cut-throat trout.

Species	Length (inches)	Sex	Head length	Head depth	Snout	Max-illary	Inter-orbital
Steelhead	12	Male	22·0	14·4	6·0	12·0	7·3
Cut-throat	12	"	25·0	15·1	7·0	14·5	7·5
Steelhead	30	"	24·0	15·5	8·8	14·8	8·8
Cut-throat	25	"	27·8	17·2	10·8	18·2	9·9
Steelhead	27	Female	21·0	14·8	6·5	11·0	8·3
Cut-throat	22	"	25·2	14·8	8·0	14·6	8·3

There is usually little difference in the length of fins of these coastal cut-throats and those of steelheads. As in the case of the other trout, the caudal is almost square in large specimens, but somewhat forked in smaller ones. The number of developed dorsal rays varies from eight to eleven, with nine or ten the usual number, and one or two shorter rays in front; anal nine or ten, occasionally, eleven developed rays preceded by one or two shorter ones; gill rakers usually 7 + 11 or 7 + 12, but some specimens have as few as fourteen, and some as many as twenty-one; branchiostegals usually ten or eleven. The cut-throat has considerably more scales than the steelhead; they are usually in 150 to 158 diagonal rows but vary widely in number, the upper limit being about 180 and the lower 143. This wide variation in the number of scales suggests that the cut-throats found in our coastal waters belong to a number of geographical races. This is not surprising when one thinks of the great extent of the area, and the great diversity of conditions under which trout develop within this area.

LIFE-HISTORY AND HABITS

Many of the cut-throats in this region spend a good deal of their lives in the sea. Until their life-history has been thoroughly investigated, it will be impossible to say what proportion of their lives is spent in the sea and what in fresh water, and whether there is any regularity to their movements from one to the other. It is probable that the proportion of their lives spent in fresh water is greater than is the case with the steelhead. In some places they are referred to as lake trout, which indicates that they are characteristically lake dwellers. This is interesting in view of the fact that in the interior the Kamloops trout occupies all suitable lakes, and the cut-throat is confined to streams, as will be discussed later.

But many cut-throats spend a good deal of time in salt water where, superficially, they come to resemble steelheads and are commonly mistaken for that species. Their longer heads, more numerous scales, and hyoid teeth, will distinguish these salt water cut-throats from steelheads. The

red coloration behind the lower jaw, from which they derive their name, is lost when the fish takes on the bluish silver colour which characterizes it in the sea.

All cut-throats, of course, spawn in fresh water. Spawning usually occurs from February to May, although as with other species the time of spawning varies with the locality, and may be later in some streams. As early as August they begin ascending streams, but this may not be a spawning migration, as they are said to follow all species of salmon to their spawning grounds. Spawning takes place in small streams. Spawning fish are very secretive, entering the smaller streams to spawn during the night and returning to deep water before daybreak.

Young specimens, five to eight inches in length, are often taken with young steelheads. Like the latter, they bear parr marks. As already indicated, cut-throats probably spend a greater part of their lives in fresh water than do steelheads, and specimens of this species of twelve to eighteen inches in length are more commonly taken in fresh water than are steelheads of the same length. On the other hand, many of them early seek the sea, and numerous cut-throats of a foot in length are to be found in salt water.

The cut-throat, in the opinion of most anglers, does not approach either the steelhead or the Kamloops as a game fish. It is not without a certain strength and sometimes fights for a considerable time, but it does not make the long runs and leaps from the water that feature the fighting of the other two species. But the cut-throat is a game-fish to be respected nevertheless. Were it not that it occurs in the same area as two of the hardest fighting game fish known, its qualities would be more highly regarded. At times it does leap from the water when hooked, and often puts up quite a prolonged struggle before being landed. It generally rises quite readily to the fly, although as a rule it takes the fly sunk and drawn as a minnow, more readily than the dry fly.

The cut-throat does not reach as large a size as the steelhead. Few exceed a weight of eight or nine pounds, and four to six pounds is a more common weight for large specimens. The greatest weight recorded is twelve pounds.

Yellowstone cut-throat trout (*Salmo clarkii lewisi* (Girard)). When one leaves coastal waters, cut-throats are not met with again in numbers until one reaches the southeast corner of the province (area 3 of the map, page 12) where, in the upper waters of the Kootenay river, including the basins of the Moyie and Elk rivers, the cut-throat is found to have been, before the introduction of the Kamloops, the only native trout. As we shall see later, the cut-throat does occur in a few isolated localities in the intervening area, but in most of the waters of the great central part of the province, the Kamloops occurs to the exclusion of all

YELLOWSTONE CUT-THROAT TROUT

Salmo clarkii lewisi (Girard)

other species of true trout. In discussing the occurrence of trout in central British Columbia, the theory is advanced (page 32), that the cut-throat has disappeared from most of the waters because of the competition of the Kamloops, which is presumably better adapted to live under the conditions obtaining in the lakes, and most of the streams of this area. If this assumption is correct, it probably means that the cut-throats in the upper waters of the Kootenay have persisted, because they gained access to this area prior to the coming of the Kamloops, or came from some source in which the Kamloops did not occur, for there are lakes and large rivers here quite similar, so far as one can see, to those in which the Kamloops thrives in the central area. The cut-throats in the basin of the Upper Kootenay have, on this theory, persisted in the lakes of this area because of the inability of the Kamloops to pass up through the canyon of the Kootenay river.

There are also cut-throats in many of the streams of the east slope of the Rocky mountains from the Bow southward. These have not yet been investigated, and no further statement concerning them will be made here.

DESCRIPTION

The cut-throat of the Upper Kootenay district is entirely different in body form, and in coloration and markings, from the coast cut-throat. In these respects it resembles the form found in Yellowstone Park, and other areas within the Missouri drainage basin in Montana and Wyoming, and is regarded as belonging to the same subspecies or geographical race, viz., *Salmo clarkii lewisi.*

These cut-throats are much less heavily spotted than the coast form. On the front part of the body there are a few scattered spots above the lateral line, but they do not extend down to this line. Behind, they are more heavily spotted, the spots from the anal fin backwards reaching from the mid dorsal to the mid ventral line. There are a few small spots on the top of the head but more on its sides, and all fins are perfectly plain. The general colour is a yellowish green, with a good deal of red on the cheeks and opercles, and often too on the sides of the body in front. In fact, these fish are sometimes quite red from head to tail, especially below.

These trout differ from the coast form also in having a deeper and more compressed body with shorter and more slender head. In these respects they approach the body form of the Kamloops trout, the similarity being further suggested by the type of spotting characteristic of these fish. They differ from the Kamloops, however, in the possession of more numerous scales, as well as in the presence of hyoid teeth and of the red coloration behind the lower jaw. They usually have their scales in about 165 rows, but they vary from 150 to 175 rows. The gill rakers are 7 + 11 and the branchiostegals usually 11, but sometimes 10 or 12.

LIFE-HISTORY AND HABITS

As already indicated, these cut-throats occupy all the lakes in this area, a condition which agrees with the habit of the species in coastal waters, but is in contrast to their occurrence in the central area to be discussed shortly. They occur also in streams, being found chiefly in the big rocky pools or behind rocks in swift water.

Spawning in this area usually occurs about the middle of April. Males are sexually mature at eight inches, and females at ten and a half inches in length. A ten ounce fish produces about five hundred eggs, and a pound and a half fish about one thousand. The eggs are buried about two inches deep in the gravel of small streams.

These cut-throats are similar in their game qualities to their relatives in coastal waters. As they occur in most waters in good numbers, and generally take the fly quite readily, there is much sport to be had in angling for them.

The results of the introduction of the Kamloops trout into the lakes of this district will be followed with considerable interest. The latter is undoubtedly a harder and more spectacular fighter, but should the cut-throat become more rare or extinct because of its introduction, and the lakes prove not entirely satisfactory to the Kamloops, there might be far less sport to be had on the same waters than formerly.

Mountain cut-throat trout (*Salmo clarkii alpestris* Dymond). In the great central area of the province (area 2 of the map, page 12) in which the Kamloops is the common trout, cut-throats occur only in a few isolated localities, usually in the headwaters of mountain streams. Their occurrence here in streams is in contrast to their occurrence in the coastal area and in the Cranbrook-Fernie district, where they are common in lakes.

In the few streams in which cut-throats occur, they are usually found in the upper reaches where they are cut off by impassable falls. Their occurrence in such situations at once suggests that these trout preceded the Kamloops into this area, coming in when the water stood at a higher level than now, that the Kamloops came later when the water stood at a lower level and exterminated the cut-throats in the lower reaches of rivers and in lakes, and that the only reason they have not completed the extermination of the cut-throat throughout this whole central area is that they have not been able to reach them in some of the upper reaches of mountain streams, because of falls which they are not able to surmount.

Opposed to this theory is the occurrence of occasional colonies of cut-throats in streams where they are not protected from competition with the Kamloops by falls. This indicates that the Kamloops does not always eliminate the cut-throat when it has access to waters in which cut-throats occur. Probably the true explanation of the persistence of the cut-throat

in these isolated localities is that only in these places are conditions more suitable for the cut-throat than for the Kamloops. The Kamloops is the better fitted for the vast majority of the waters found in this great central area, and has gradually eliminated the cut-throat through the stress of competition.

The localities from which these cut-throats are known are: Isaac, Frog, and Canyon creeks, flowing into the Columbia river near Revelstoke; Crazey, Yard, and Frog creeks, tributaries to Eagle river and Mable lake in the Shuswap area, some small lakes on Griffin mountain, and Six-mile and Nine-mile creeks, flowing into the west arm of Kootenay lake. Cut-throats are also found in Rosebud lake, south of Nelson, and in at least one lake at considerable elevation in the Nelson area, and it is probable that they are to be found in a number of other similar areas in this part of the province.

As might be expected from the widely different conditions under which these trout are found, there is a great deal of variation between specimens from the different localities. Their study has been further complicated by the planting of cut-throat fry from other regions into some of the waters in question.

DESCRIPTION

The following description is based on a study of the small stream-inhabiting cut-throats from the Revelstoke district.

In general coloration they are brownish, darker on the upper sides and back, and lighter below. The belly is greyish and there is often a streak of pink between this colour and the brown of the sides. The gill covers, too, often bear a pinkish colour, and the red streak along the under side of the lower jaw is a prominent feature of the coloration of this small stream-inhabiting cut-throat. The spotting pattern is quite characteristic in these trout. On the front part of the body there are few or no spots, but posteriorly the spots increase in size and number so that by the time the caudal peduncle is reached, it is closely covered with fairly large spots. The dorsal and caudal fins are spotted, the anal usually has a few spots, while the pectorals and ventrals are clouded.

They differ from the coast form of cut-throat in having shorter heads, deeper and wider bodies, deeper caudal peduncles, longer pectoral and ventral fins, and larger eyes. In some of these characters, for instance, the shorter head, deeper bodies, and thicker caudal peduncles, they resemble the Kamloops. The larger size of their lower fins is perhaps correlated with the swiftness of the streams in which they live, longer pectoral and ventral fins being better adapted to balancing in currents. They all have hyoid teeth, and the red coloration behind the lower jaw.

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FOOD AND OTHER HABITS

Some information on the food of these trout has been obtained by examination of the contents of the stomachs of forty-four specimens taken by Mr. Higgs in the vicinity of Revelstoke in August and September, 1929. On account of the small number of stomachs represented in the collection, the shortness of the period over which the collection was made and the limited area from which the fish came, these results cannot be taken as indicating in any general way the food of the cut-throat trout, but they are of interest nevertheless, in giving a certain amount of information on the food habits of this species. The specimens represented by this collection were from seven to thirteen inches in length. They were all taken above falls in creeks in the vicinity of Revelstoke, B.C., between August 18 and September 29, 1929—thirty from Isaac creek, eight from Frog creek, and six from Canyon creek. Eighty-six per cent of the contents of these forty-four stomachs consisted of insect material. Half of this consisted of larval insects secured below the surface of the water, and half of adult insects taken from the surface. Of the other 14 per cent making up the stomach contents, practically all consisted of indigestible material, such as small stones, pieces of wood, etc.; scarcely any organisms, other than insects, had been eaten. The larval and other immature insects which the trout secured from the bottom, and other situations below the surface of the water, consisted very largely of caddis worms and the nymphs of mayflies, the former being very much more abundant than the latter. There were also a few nymphs of stoneflies. A few adult or terrestrial forms of mayflies, stoneflies, and caddis-flies had been eaten, but the bulk of terrestrial insects consisted of ichneumon flies, pentatomid bugs, dipterous flies, moths, ants, spiders, beetles, wasps, craneflies and sawflies.

In most of the creeks in which these cut-throats are found they are very numerous, it being possible to take a dozen or more from one large hole. In such habitats they do not reach a very large size. Occasionally, specimens are taken from the lower part of the streams, and these are usually larger, but the largest specimens taken in the district, according to Mr. A. Higgs, of Revelstoke, would be about fourteen inches.

The mountain cut-throats are similar in their qualities as game fish to the coastal forms. When hooked, they usually make a rush for the deeper and quieter parts of the stream. Unlike the Kamloops they do not carry on their fight in the current unless forced to do so. They rise readily to the fly, and this attribute is one of their most attractive features. If two flies are used on a leader, it is said to be not uncommon to hook and land two fish at one cast.

Almost any type of fly will take them, but locally the brighter patterns are preferred—Royal Coachman, Parmachene Belle, Grizzly King, Montreal, Professor and Queen of the Waters being the favourite ones.

HYBRID TROUT

Fertile hybrids between the Kamloops trout and the cut-throat trout of the district are said to have been produced at the hatchery of the Cranbrook Rod and Gun Club.

In 1923, Mr. H. J. Ryder, of the Fish Cultural Service, Department of Fisheries, who was stationed at the Cranbrook hatchery, crossed the native cut-throat trout and the Kamloops. The Kamloops used in this experiment were secured from Monroe lake, into which this species had been introduced in 1918.

In 1926, a few of the hybrids became mature and eggs from hybrid trout were successfully fertilized by milt from male hybrids. Much larger numbers of fry were raised from hybrid parents in 1927 and 1928. The hybrids are said to attain a larger size than either the cut-throat or the Kamloops in the same waters. They are also said to break water, when hooked, a characteristic of the Kamloops that is lacking in the cut-throat. Examination of specimens, regarded locally as hybrids, showed that they possessed some characters of each of the parent forms, and there is no reason to doubt that hybrid trout have been produced as stated.

ATLANTIC SALMON

Salmo salar Linnaeus

Atlantic salmon have been introduced into the waters about Vancouver island, and quite a number of specimens have been reported as having been taken in some years by anglers. Only two specimens were received in connection with the studies reported herein. One had been taken in Cowichan lake, September 3, 1913; it was less than six inches long. The other, eleven inches in length and nine ounces in weight, was taken in the Lower Cowichan river on May 31, 1926.

In the opinion of A. A. Easton, Fisheries' Inspector at Duncan, the Atlantic salmon introduced into that district may have stayed in the lakes and rivers, as they have done in New Zealand, where they act like land-locked fish. The planting of this species in British Columbia waters has now been discontinued, on account of the lack of success attending its introduction.

This species may be distinguished from the steelhead by its larger (fewer) scales, there being about 120 diagonal rows as compared with 130 or more in the steelhead. The salmon also has fewer rays in its anal fin, nine as compared with ten or eleven in the steelhead. The caudal fin of the salmon is usually unspotted, being merely clouded, while in the steelhead it is spotted.

BROWN TROUT

Salmo trutta Linnaeus *(S. fario)*

The brown trout is the native trout of Europe, being found in Great Britain, France, Germany and other central European countries. It is also called German brown trout. The Loch Leven trout is the form of the brown trout native to Loch Leven, the lake made famous by Scott's poem "The Lady of the Lake." It differs slightly from the typical form in markings and coloration. Brown and Loch Leven trout have been rather extensively introduced into various sections of the United States and Eastern Canada but the consensus of opinion of those who have had experience with this trout in America is that it should not be introduced into any waters where conditions are still suitable for native species.

CHAR

The char are distinguished from trout in that the vomer, the bone in the centre of the roof of the mouth, possesses teeth only on its head, in the form of a small patch. The shaft of the bone behind the raised head is sunken and boat-shaped. In the trout, on the other hand, the shaft of the vomer bears a zig-zag row of teeth on its shaft. These differences are illustrated in fig. 2.

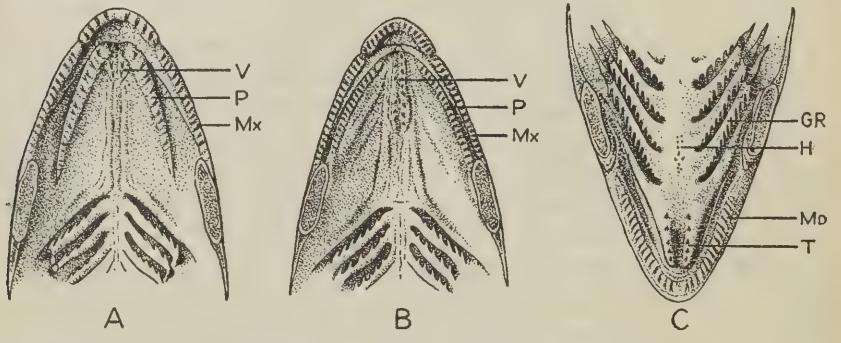


FIG. 2. Jaws and teeth of char and trout. A, Upper jaw and roof of mouth of char (*Salvelinus*); B, Upper jaw and roof of mouth of trout (*Salmo*); C, Lower jaw, tongue and lower half of gill arches of cut-throat trout (*Salmo clarkii*). V—vomer or vomerine bone with teeth; P—palatine bone with teeth; Mx—Maxillary; H—hyoid teeth on base of tongue; T—teeth on tip of tongue; MD—Mandible; GR—gill-rakers.

Char as a group are more brightly coloured than trout, the Dolly Varden and eastern speckled trout for instance being marked with salmon-coloured or red spots. They also usually have smaller scales. As a class too the char are found farther north and in colder water than trout. The name char is said to be derived from the Celtic *cear*, blood or *ceara* red in allusion to the colour of the belly. See also page 5 for a discussion of the term char.

DOLLY VARDEN

Salvelinus malma (Walbaum)

DOLLY VARDEN

Salvelinus malma (Walbaum)

This char is also known as bull trout. It is of general distribution in British Columbia; it does not occur in all of the waters of the province, but it is absent from relatively few and there are no large areas in which it does not occur at all, as in the case of each of the three species of trout already considered. It occurs in the salt water as well as in fresh water, although, like other members of the family, it must return to fresh water to spawn. Like other members of the family too, it exhibits wide variations in the size to which it grows, and in coloration.

DESCRIPTION

The colour varies from greenish, greyish or brownish, to silvery, depending on conditions. The smaller specimens in clear streams and lakes are greenish with salmon-coloured spots on the sides. In dark water the fish takes on a brownish hue, the spots becoming yellowish. Large specimens in lakes and large rivers are silvery, the spots becoming so pale as to be easily overlooked. The back lacks the dark vermiculations characteristic of its near relative the eastern speckled trout, but it resembles that species in having its lower fins edged with white. The belly is usually white or cream-coloured. In the sea the Dolly Varden is almost plain silvery.

In comparison with a Kamloops trout or a steelhead the Dolly Varden's body is more rounded, that is wider and not so deep; the head is long and not so thick through as that of the trout; the snout long and pointed; the mouth large and the eye small. The caudal peduncle is long and slender, while the fins are comparatively short. In small specimens the body is quite slender, but in large ones it assumes a more robust form.

The proportionate measurements of various body parts of the Dolly Varden are as follows:—

Length (inches)	Sex	Head length	Head depth	Eye	Snout	Max-illary	Inter-orbital
15	Male	25·3	14·0	3·8	6·8	14·0	7·2
15	Female	24·7	13·7	3·6	6·8	13·7	6·4

The length of the fins in per cent of the body length are as follows: dorsal 14·0, anal 12·5, pectoral 15·5, ventral 13·0, caudal 18·5. The dorsal usually has eleven and the anal nine fully developed rays preceded in each case by one or more shorter rays; gill rakers are usually 6 + 10, but vary in number from 14 to 17; branchiostegals 13 or 14. The scale rows range from 196 to 239, the average being about 220.

HABITS

In gameness, the Dolly Varden is not the equal of the trout, even the cut-throat surpassing it as a fighting fish. It is inferior also to its near relative the eastern speckled trout. Fair sport, however, is provided in fishing for the larger specimens with light tackle. The chief difficulty in handling these large specimens on such tackle is the strain of their weight when they get in swift water. When hooked they do not break water, a few jerks usually being the extent of their resistance to being pulled in. Occasionally, one makes a few short rushes when brought to the boat, but there is usually no difficulty in landing them.

They take almost any sort of bait or lure quite readily, and do not appear to be easily alarmed. Many of the smaller specimens are taken on the artificial fly, but spoons or baits of various kinds are generally used for the larger ones. They will often bite repeatedly after being hooked and lost, and the ease with which they may be taken is, perhaps, the chief element in whatever appeal they have as game fish. Under some conditions however, such as in cold, swift streams, the Dolly Varden displays more gameness than usual.

Trout fishermen seldom show any enthusiasm over the Dolly Varden, not only because it lacks those qualities of dash and fight which they respect in a fish, but they regard it as an enemy of the trout. These prejudices appear to have some basis, for many of the larger specimens have been found to contain trout in their stomachs. Those not directly destructive to trout are serious competitors of the latter for food, as they prey on kokanees, a favourite food of the trout. Other fish found in their stomachs include chub (*Mylocheilus caurinus*), and Rocky mountain white fish (*Prosopium williamsoni*). They appear to be very voracious, the average number of kokanees found in their stomachs being much higher than in the case of the trout. They do not confine themselves to fish, for mice, moles, frogs and even birds have been found in their stomachs.

The stomachs of a few specimens from the same region as the cut-throats, whose food is reported on page 34, have been examined for comparison with those of the latter species. Their food was found to be practically identical to that of the cut-throat, indicating that the abundance of these fish in the streams is a serious drain on the food supply which supports the trout.

The weight of the Dolly Varden varies with the size and character of the waters in which it is found. In the smaller creeks it seldom exceeds a weight of two pounds, but in large lakes and rivers it is not uncommonly taken up to twenty pounds, and even larger ones are sometimes reported.

The name of this char, according to Lambert, "is to be derived indirectly from Dickens and the time of his tours in the United States,

which produced a Dolly Varden craze in hats and some kinds of calico patterns, of which one with pink spots was supposed to be the correct Dolly Varden pattern. On seeing the fish for the first time, some young lady is supposed to have exclaimed that it was a 'Dolly Varden trout' and the name appears to have been generally adopted."

This species is of some value as a food fish in salt water, but in British Columbia waters its value in this connection is comparatively small as compared with that of the same species in Alaska, and along the northern shores of Canada.

NOMENCLATURE AND RELATIONSHIPS

Various scientific names have been used for this species, including *Salvelinus malma*, *Salvelinus parkei* and *Salvelinus spectabilis*. No attempt will be made here to consider which of these names is correct for the British Columbia species and the name which is adopted, *Salvelinus malma*, is used with this reservation.

The Dolly Varden is a very close relative of the Arctic char of Europe, the fish to which the name char was originally applied. Besides the forms of the Arctic char found in the lakes of the British Isles, Switzerland and other countries of north Europe, a marine form occurs on the coasts of Finland, Spitzbergen, Iceland, Greenland, northern Canada, Alaska and Siberia. In Canada, as in Europe, the char forms lacustrine colonies, which are likely to differ in some of their characters from the sea-going forms. Various land-locked, lake forms have been described as distinct species, especially in eastern America. Thus in a number of lakes in Quebec we have Marston's trout or the red trout of Quebec as it is often called (*Salvelinus marstoni*); in Maine and New Hampshire, the Sunapee trout (*Salvelinus aureolus*) and the Oquassa trout (*Salvelinus oquassa*) and in a small lake near lake Temagami in Ontario, the Aurora trout (*Salvelinus timagamiensis*). It should be noted, however, that the Dolly Varden in British Columbia is little different from the sea-going form so common in the northern regions of Europe, Asia, and North America, and should perhaps be regarded as a sub-species of the Arctic char, viz. (*Salvelinus alpinus malma*).

GREAT LAKE TROUT

Cristivomer namaycush (Walbaum)

This char has several common names, including grey trout, mackinaw trout and namaycush. It occurs in British Columbia from the region of the Shushwap northward. It appears to be entirely absent from the Columbia drainage system in the province, but is common in most of the larger lakes of the Fraser watershed. The waters from which there are

records of its occurrence in British Columbia are Shushwap lake, Victor lake, Fraser lake, Stuart lake, and Francois lake, but it is undoubtedly common in many of the lakes in the neighbourhood of these. This species agrees with the other chars in being typically northern in its distribution. It occurs in lakes where water of some depth is to be found, from New Brunswick and Maine, through Quebec, Ontario, and the northern parts of the prairie provinces, into northern British Columbia. It appears to be less prone to resort to salt water than most species of trout and char.

In colour the lake trout is usually greenish, greyish or brownish, the sides being marked with many light spots, whose size varies in different fish from that of three to six scales to that of twelve to fifteen scales; the spots are smaller on the upper sides and back. The dorsal and caudal fins are dusky with many rounded, light spots.

This species resembles the Dolly Varden in having a long head, long snout, large mouth and small eye. The caudal fin is deeply forked and widely spreading. The scales are in about two hundred diagonal rows.

Under ordinary circumstances the lake trout is not very highly regarded as a game fish, and in British Columbia it suffers in this respect in contrast with the Kamloops trout, which is found in most of the waters in which it occurs. In Shushwap lake the grey trout, as it is called, is usually taken by trolling with heavy tackle, such as a weighted line or copper line and heavy rod and reel. From three hundred to eight hundred feet of line are used, from two hundred and fifty to six hundred feet being let out. Spoons are the lures most commonly used. When caught on such tackle, especially when fished from a motor boat, these fish naturally are not able to put up much of a fight, and when brought to the surface are gaffed without trouble. Small specimens, when taken in the shallower waters of cold lakes, as they sometimes are, and on light tackle, are not inferior to the Dolly Varden in gameness.

The lake trout sometimes attains a very considerable size, individuals of sixty pounds having been reported from some of the northern lakes, and thirty pound specimens are not uncommon in others.

EASTERN SPECKLED TROUT

Salvelinus fontinalis (Mitchill)

By far the finest of the char is this speckled beauty which is native to eastern North America.

In British Columbia it does not usually exhibit those game qualities which in its native waters have earned for it the name of being the finest of game fishes. This difference is probably due to the difference in the habitats of the fish in the two areas. In the east, the speckled trout prefers

the coldest, and clearest of waters, but in British Columbia it has usually been planted in shallow lakes or sluggish streams, waters in which the native trout are not found or do not thrive. In such waters the speckled trout is usually somewhat sluggish in comparison with the Kamloops. Under more favourable conditions it is the equal of that species.

The speckled trout is perhaps the most beautiful of the salmonoid fishes. The general coloration is usually olive green, darker on the back and lighter on the sides. Especially characteristic of it are the dark vermiculations or irregular markings on the back. The sides are usually rather lustrous and are marked with numerous lighter greenish spots, some of which have red centres surrounded by blue borders. The dorsal fin bears dark, wavy markings, the caudal and lower fins are pinkish or orange. The front margins of the lower fins are white. Specimens from dark-coloured waters are of a general brown tinge instead of the bright green of fish from clear, cold waters.

The speckled trout rises readily to the artificial fly, and in British Columbia is usually taken with the same tackle used in taking the smaller Kamloops trout.

In many of the waters into which the speckled trout has been introduced in British Columbia, it has made a remarkable growth. Its size, in comparison with the native Kamloops in Tum Tum creek near Revelstoke, and the ultimate effect on that species, has already been discussed (page 22). In Leviathan lake, near Kaslo, a specimen weighing two pounds and a half dressed was taken during the second summer after the lake was stocked. Specimens weighing five and a quarter pounds have been taken in Big Sheep creek near Grand Forks.

PACIFIC SALMON

Oncorhynchus spp.

Of the five species of Pacific salmon only two or three can be regarded as of any interest to the angler.

Spring salmon, also called Tyee, Chinook and King salmon (*Oncorhynchus tschawytscha*) is not only the largest of the Pacific salmon, but the best of them from the anglers' point of view. The vicinity of the Campbell river, Vancouver island, is the headquarters of the famous Tyee Club of British Columbia, and to this place come sportsmen from all parts of the world to match their skill against these large, gamey salmon. The Tyee Club has tried to encourage the use of light tackle in the capture of these fish, in place of the trolling with heavy lines formerly so common. The Club hopes to standardize light tackle for taking tyee up to seventy-five pounds in weight.

Usually the spring salmon occurs at such depths as to make the use of heavily weighted lines a necessity, but in some localities, notably along the edges of the bars on Discovery passage just off the mouth of the Campbell river, trolling at a depth of ten to twenty feet by means of light rod and line tackle is successful. Under such conditions tyee fishing is a thrilling sport.

Coho salmon (*Oncorhynchus kisutch*), will sometimes take the fly and a few are caught by this means for sport, but trolling is the favourite method of fishing for them. In Tlell river, Queen Charlotte islands, large numbers of cohoes running to spawn are taken with spinners by the residents.

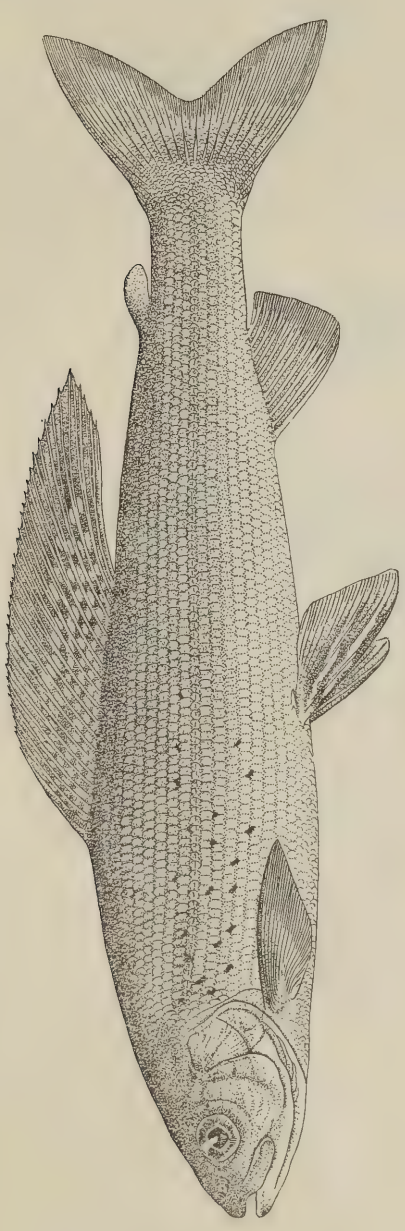
To one who wishes a change from lake or stream fishing for trout, the pursuit of tyee and coho offers a new adventure in angling.

Kokanee. In many of the lakes of British Columbia the sockeye salmon is found as a permanent fresh water resident. These fish never go to sea, but spend that portion of their lives which is usually spent in salt water in some lake. These fresh-water sockeyes have been given the subspecific name *kennerlyi* to distinguish them from the sea-going form. Their scientific name is therefore, *Oncorhynchus nerka kennerlyi*. They have received many common names, including kokanee, kikanniny, silver salmon, little redfish, Kennerly's salmon and Kennerly's trout. Some of these names are likely to be misleading, the term silver salmon, for instance, being also applied to the silvery form of the Kamloops trout and also to the Coho salmon.

The kokanee is found in a great many lakes in the interior of the province, including Kootenay, Okanagan, Shushwap, Christina, Woods and Kalamalka lakes.

These fresh-water sockeyes vary much in size in different lakes and in the same lake from year to year. In Christina lake, for instance, the greatest weight to which they grow is about one pound, and the smallest weight of adults about one-fifth of a pound. It is said that in any one year the mature fish are all of the same size, that is when they grow to be one pound in weight they are all of that size, whereas in other years the adults will all be of a uniform weight of a few ounces each. A few kokanees of a greater weight than a pound have been reported, but in general one pound appears to be the maximum weight, while the average is considerably less.

Their habits and life history are little known. They probably mature in their fourth year, and agree with the marine form in the fact that they



GRAYLING
Thymallus signifer (Richardson)

die after spawning. On the approach of the spawning season in autumn, they assume the red colour and the structural transformation of the marine sockeye; at other times they are bright silvery bluish.

The kokanee is seldom taken on the fly or by trolling, although occasionally one is taken on such tackle. In some places quite a number are caught by bait-fishing in from six to fifteen feet of water.

It is an excellent food fish, its flesh being a deep reddish colour and quite tasty. It is of great importance as a food for trout, as noted elsewhere in this publication.

The conservation of this species is a matter which should receive the attention of those interested in our game fish, not only on account of its value as food for trout, but also because of its possibility both as a food and game species.

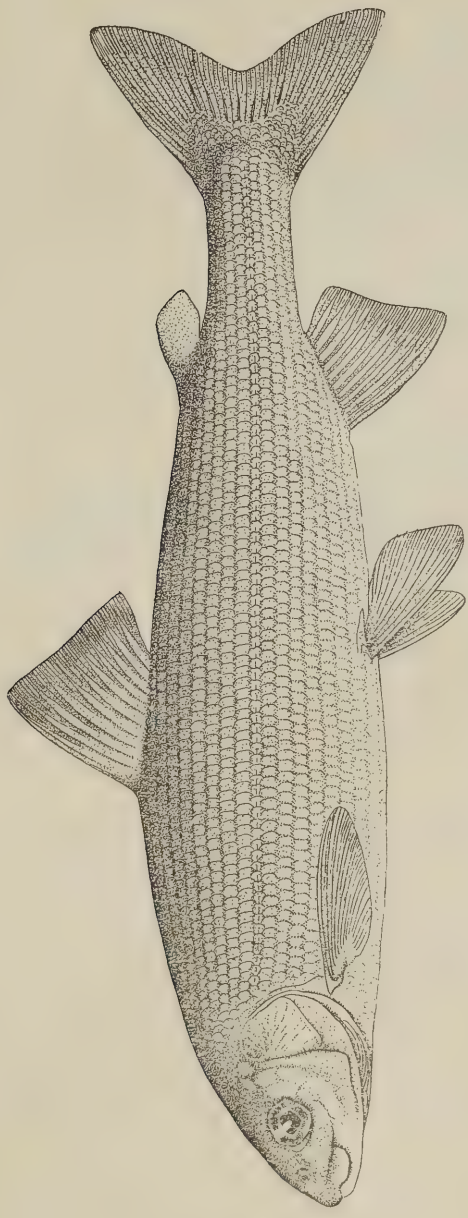
SPECIES ALLIED TO TROUT

Two species allied to trout, which are of some value as game fish and about which there is a great deal of confusion, are the grayling and the Rocky mountain whitefish.

Grayling are sub-arctic fishes of Europe, Asia and North America. They are especially characterized by their high dorsal fin. Grayling are often regarded as belonging to the same family as the trout and char, but sometimes they are placed in a family of their own (Thymallidae). They resemble trout in the possession of an adipose fin, the small fleshy fin on the back between the dorsal and caudal fins, and in general structure. They differ in the possession of smaller mouths and jaws and weaker teeth. Fished for on light tackle they provide considerable sport but they lack the strength of the trout.

The grayling is known to occur in Atlin lake in northern British Columbia. It also occurs in northern Alberta and Alaska. These fish have been little studied, but it is probable that the British Columbia species is the same as that described from northern Alberta, *Thymallus signifer*.

The Rocky Mountain whitefish (*Prosopium williamsoni*) is often erroneously called grayling. It somewhat resembles the common whitefish, the valuable food fish of the Great lakes and other large Eastern lakes, but is not so closely related as the name suggests. It too is often regarded as belonging to the trout and char family, but sometimes is placed with the ciscoes or lake herrings in a separate family, the Coregonidae. The Rocky Mountain whitefish will often rise to an artificial fly, and in swift, cold mountain streams shows some of the spirit characteristic of a game fish.



ROCKY MOUNTAIN WHITEFISH
Prosopium williamsoni (Girard)

THE CONSERVATION OF BRITISH COLUMBIA TROUT

The conservation of any form of wild life must be based on knowledge. That fact is so apparent that it requires no argument to convince us of its truth. In any water the conditions necessary for the successful propagation of trout must be maintained or we cannot hope to have trout living in it in adequate numbers. In comparison with what we need to know to make the greatest success of trout propagation, our present knowledge is very scanty; hence the necessity for research to discover new facts. But we already know some of the facts necessary to the conservation of our trout, and if these were generally understood and the knowledge acted upon, we should be going a long way towards the perpetuation of our trout.

One of the first requisites is food; many people seem to think that water is all that is needed. A moment's thought, of course, convinces anyone that unless a body of water contains adequate food it cannot support a large population of trout. It is necessary too that there be food for trout at all stages of their growth. If a lake contains only a scanty supply of food for fry and fingerling trout it will not stand much fishing, even though it teems with food for large trout. The situation can perhaps best be realized if we think of the condition in a small pond, which produces enough food suitable for tiny trout to bring only ten or twelve through their first year. Having once got through their first year, the trout find plenty of food in the pond of a size suitable to them. Such a pond, in the absence of fishing, would come to contain quite large numbers of trout, but if, when it came to be fished, twenty fish a year were taken out, it would soon become depleted, because only ten or twelve are being added to its population each year. It, therefore, becomes clear that a body of water must have adequate food for trout at all stages of growth.

Reference has already been made to the circumstance that Kamloops trout begin to feed on fish in numbers when they are about sixteen inches in length, and that it is only in exceptional cases that they grow to a large size in the absence of a supply of fish on which they can feed. Sometimes we find that lakes in which there are plenty of kokanees to support a good population of adult trout are, nevertheless poor trout lakes. Such a condition, it has been suggested, is due to the scarcity of food for some of the younger stages of trout. If such is the cause of the low productivity of a lake, conditions will not be improved by planting more fry or fingerlings in it, for this will only increase the competition among the young trout for the already too scanty food supply.

The logical way to improve fishing in such a lake is to raise the trout to a size at which they can find adequate food in the lake. A number of the Rod and Gun clubs of the province have already made a start in the direction indicated, by constructing ponds in which the fingerling trout

supplied them by the hatcheries, are reared to some size before they are liberated in the waters in which these clubs are trying to improve the angling. In the extension of such a scheme, probably, lies the possibility of making good trout waters out of many which are now poor.

A lake which has a considerable area of water under thirty feet in depth, together with some deeper water, will probably produce more trout than one in which the shores are steep and the water deep a short distance out. The bottom in the shallower areas often supports a large population of fresh-water shrimps *(Gammarus)*, insect larvae, small molluscs and other organisms of similar size. Here the small trout find most of their food. These shallows also produce much food for larger trout as well, but the latter range into the deeper water, especially if there they find fish on which to feed. The relationship of the shallow and deep water to trout production is suggested in the accompanying sketch.

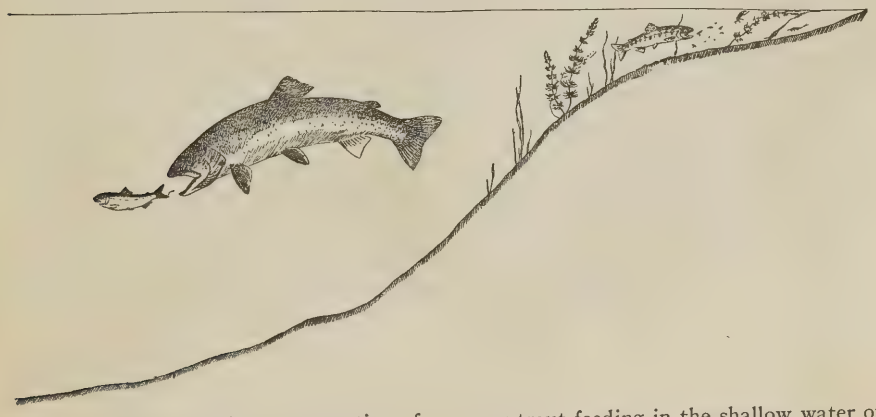


FIG. 3. A diagrammatic representation of a young trout feeding in the shallow water of a lake where numerous organisms of a size suitable for small trout occur and a large trout feeding on fish in the open, over deep water.

Since the shallow water fringing the shore is probably of such critical importance in determining the productivity of lakes, every effort should be made to keep this area as free as possible from interference. Too often the shallow borders of lakes are ruined as feeding grounds for trout by the throwing into them of refuse of all sorts. The placing of any foreign material into the waters should be strictly forbidden, and every effort made to maintain natural conditions on the bottom, especially in the shallower areas.

Pollution of any kind is likely to be injurious to trout. The substances put into the water need not be directly poisonous to fish to be injurious to fish-production. If they interfere with the production of any of the food animals on which trout live, or of any of the microscopic plants or animals on which in turn these food animals live, the polluting substance

will in the end interfere with trout production. Further, a substance put into the waters need not be directly, or at once injurious to the microscopic life, or to the larger life which feeds on it and serves as food for trout, or to the trout themselves; if in decomposing it uses up oxygen, and so lowers too much the supply of this gas in the water, the trout will suffer, for oxygen is just as essential to fish as it is to animal life on land. Relatively few of the waters of the province are yet seriously polluted, but with the growth of population and industry, anglers will have to be constantly on guard to see that pollution of the waters is not permitted to increase.

Even under natural conditions, such as originally existed in the province, the productivity of our waters is not likely to have been as high as that of some regions. Although trout eat other fish, insects, and similar animals, and these in turn eat smaller animals, in the last analysis all animal life depends on plants. In the waters, the plants which serve as food for the tiny animals are microscopic. All plant life in turn depends on inorganic constituents, which, in the case of water, are leeched out of the soil and carried in solution by the waters of rivers and lakes. There is less food required by plants to be found in the waters of a rocky region, than in those of a region covered with rich soil. The same elements that produce rich vegetation on land produce a rich crop of microscopic vegetation in the water. Without an abundant supply of microscopic vegetation, a high production of fish is impossible. For this reason we must reconcile ourselves to the fact that on account of the geological formation and history of a very considerable area of Canada, our waters are not naturally as rich, as we would like to have them, in the elements on which fish life ultimately depends. However, what our waters lack in quantity of fish is more than made up for in the high quality of the fishes which they do contain.

In streams subject to floods at certain seasons and very low water at others, conditions are far from ideal for trout. Rushing flood waters, which are usually laden with sediment, scour out the stream beds, and make them incapable of supporting any very large population of the little animals on which trout feed. The low water found in these streams at other seasons is equally unfavourable, for only a few fish can find sustenance in a small quantity of water. Streams in which there is a fairly uniform flow throughout the year, produce more fish than the same streams would do if they were subject to alternate periods of flood and low water.

Consideration of the factors affecting fish life discussed above, should convince us that the number of trout which our waters are capable of producing is limited. If we take more than a certain number of fish from any body of water depletion will ultimately result. This fact, of course, is generally understood, but the disastrous effects of depletion have not been realized. It has been felt that if game fish became scarce in a body

of water, all that was necessary was to raise more fry and fingerlings in hatcheries and plant them in the depleted waters. We are only beginning to realize that depletion involves more than the decrease in the numbers of desirable fish; it often results in the increase of less desirable species. Under natural conditions there is more or less of a balance maintained between the various species of fish, and other organisms occupying a body of water. If this balance is seriously upset, so that the enemies and competitors of trout become very numerous, it becomes increasingly difficult for trout, especially young trout, to survive. Depletion is a far more serious matter than we have thought, and for that reason it should be the aim of those interested in the conservation of our trout, to prevent the numbers of trout in our waters falling to too low a level.

We may as well face the fact that our waters never will produce enough fish to permit everyone to have all the fish he would like. Anglers must learn to be satisfied to take only their share of fish. To the true sportsman there is more to fishing than fish. He takes a greater proportion of his joy in being out of doors, in the practice and improvement of his art, and in matching his skill against that of the fish, not forgetting to give it an even chance for its life, than he does in bringing home a heavy creel. When everyone who goes out to fish is a sportsman in the truest sense of that much-abused term, the problem of the conservation of our game fish will not be so pressing as it is to-day. Of the two elements necessary to the sport of fishing—the fisherman and the fish, the fisherman is perhaps more in need of cultivation than the fish.

INDEX TO NAMES